Use of PlasmaJet for Peritoneal Carcinomatosis in Ovarian Cancer

Enrico Panuccio, MD,† Karin Leunen, MD, PhD,* Els Van Nieuwenhuysen, MD,* Patrick Neven, MD, PhD,* Sandrina Lambrechts, MD,* and Ignace Vergote, MD, PhD, FACS, FSPS**

Objective: This study aimed to assess the role and complications of extensive cytoreduction with PlasmaJet (Plasma Surgical, Roswell, Ga) in ovarian cancer with peritoneal carcinomatosis.
Materials: All patients undergoing primary, secondary, or interval debulking surgery for ovarian cancer and treated with PlasmaJet between October 2013 and February 2015 were analyzed.
Results: Nineteen patients were enrolled. The median operative time was 270 minutes, median blood loss was 700 mL, and median length of stay was 9 days. In all patients, complete resection of all macroscopic disease was achieved.
We used PlasmaJet to remove peritoneal carcinomatosis on the abdominal peritoneum, intestinal mesentery, bowel serosa, and diaphragmatic region. Overall, we treated 66 organs with PlasmaJet in our series. No bowel or urological fistulas were observed. According to the Clavien-Dindo classification, 13 adverse events were recorded at grade 2 or lesser. We observed only 1 grade 3 adverse event. No postoperative mortality was recorded.
Conclusions: In our series, the PlasmaJet seems to be an efficient device for tumor ablation or dissection to obtain complete resection of all macroscopic disease in patients with peritoneal carcinomatosis.

Key Words: PlasmaJet, Peritoneal carcinomatosis, Surgery, Ovarian cancer

Received May 29, 2015, and in revised form May 16, 2016.
Accepted for publication May 22, 2016.

(*Int J Gynecol Cancer* 2016;00: 00–00)

Epithelial ovarian cancer (EOC) is the first cause of death from gynecological malignancies. Because of the lack of specific symptoms in early disease, more than two thirds of EOC are diagnosed in the advanced stage.

Currently, the standard primary therapy for patients with advanced EOC is primary debulking surgery aiming to remove all visible tumor tissue followed by adjuvant chemotherapy with paclitaxel and carboplatin.

Recently, interval debulking surgery after 3 courses of neoadjuvant chemotherapy has become a possible treatment option in patients unable to undergo complete resection during primary debulking.[1–4] Complete resection of all macroscopic disease at primary debulking has been shown to be the single most important independent prognostic factor in advanced ovarian carcinoma both at primary and interval debulking surgery.[2–5] In some patients, obtaining the goal of no residual tumor at debulking surgery is difficult because of extensive disease on the bowel, diaphragm, and peritoneum. In this setting, PlasmaJet (Plasma Surgical, Roswell, Ga) can help the surgeon to obtain an optimal debulking. *Secondary cytoreductive surgery* is defined as surgery performed after the completion of the primary treatment and a disease-free period. Until data from ongoing

*Division of Gynecologic Oncology, University Hospital Leuven, Leuven Cancer Institute, KU Leuven, Leuven, European Union; and †Department of Gynecology and Obstetrics, University of Turin, Mauriziano Hospital, Turin, Italy.

Address correspondence and reprint requests to Ignace Vergote, MD, PhD, FACS, FSPS, Division of Gynecologic Oncology, Herestraat 49, B-3000 Leuven, European Union.
E-mail: Ignace.vergote@uzleuven.be.
The authors declare no conflicts of interest.

ISSN: 1048-891X
DOI: 10.1097/IGC.0000000000000788

TABLE 1. Baseline characteristics

Characteristics	N (%)
Histology	
Serous low grade	4 (21%)
Serous high grade	14 (74%)
Granulosa cell tumor	1 (5%)
FIGO stage (at diagnosis)	
IC	2 (10%)
IIIB	2 (10%)
IIIC	10 (53%)
IVB	5 (26%)
Presence of ascites	2 (10%)

FIGO indicates International Federation of Gynecology and Obstetrics.

trials will be mature (GOG 213 and AGO-OVAR DESKTOP 3), the evidence is based on retrospective studies, suggesting a benefit of secondary surgery in selected patients.[6]

The PlasmaJet technology uses neutral plasma energy to desiccate and vaporize soft tissues. Energy from argon plasma is rapidly dissipated as light, kinetic energy, and thermal energy. The thermal energy produced by the argon plasma also has unusual properties in that there is a rapid loss of energy from the particles within the plasma, resulting in only superficial tissue effects and minimal lateral thermal effects.[7] Surprisingly, only limited minimal data exist on the clinical application of the PlasmaJet for cytoreduction in peritoneal carcinomatosis,[7] and data from secondary debulking or in interval debulking in EOC are lacking or only reported as a case report.[8]

MATERIALS AND METHODS

All patients with widespread peritoneal carcinomatosis treated with the PlasmaJet scalpel during laparotomy for ovarian cancer were analyzed. The senior author (I.V.) operated on all patients with the assistance of the coauthors. PlasmaJet was used to treat peritoneal deposits of cancer metastases or tumor nodules on the serosal surface or mesentery of the small and large bowel as well as tumor deposits on the surface of the liver, diaphragm, and peritoneum. For diffuse tumor plaques, the PlasmaJet was used in a *painting* technique, covering the entire tumor surface with a continuous sweeping motion in accordance with the technique described by Bristow[9] for Argon-beam coagulator. In all cases, a median laparotomy was performed. Complete adhesiolysis, total hysterectomy, bilateral salpingo-oophorectomy, omentectomy, and resection or a vaporization of all affected organs (small or large bowel, peritoneum, spleen, diaphragm, liver, etc.) was performed. Paraaortic and pelvic lymphadenectomy were performed when clinically indicated.

The following characteristics were recorded: age, comorbidities, International Federation of Gynecology and Obstetrics stage, histological type, postoperative residual tumor, presence of ascites, duration of surgery, previous chemotherapy, organs operated on with the PlasmaJet, and previous surgery for ovarian cancer. Estimated blood loss, length of hospital stay, major/minor postoperative morbidity, adjuvant therapy, and date of last follow-up and disease status were also recorded.

Statistical analyses were performed using SPSS 13.0 software (SPSS, Inc, Chicago, Ill). Values are presented as median and percentage.

RESULTS

From October 2013 to February 2015, we included 19 patients who underwent cytoreductive surgery with PlasmaJet. The median age was 63 years (39–85), and median BMI was 22.8 kg/m^2 (18.5–48.4 kg/m^2). At the time of surgery, 3 (16%) patient underwent primary debulking and 4 (21%) secondary debulking surgery. The remaining 12 patients (63%) were submitted to interval debulking surgery after neoadjuvant chemotherapy. Eleven patients (58%) had medical comorbidities, median operative time was 270 minutes (range, 100–420 minutes), and median blood loss was 700 mL (range, 100–2500 mL). Table 1 shows the baseline characteristics.

Four patients did not receive chemotherapy before surgery (3 primary debulking and 1 granulosa cell tumor). Twelve patients received neoadjuvant chemotherapy (carboplatin-paclitaxel, 3–6 cycles). After secondary debulking, all patients received 6 cycles of carboplatin-paclitaxel. The surgical procedures performed on all 19 patients are listed in Table 2. Extensive lymphadenectomy was performed only in patients with pathologic lymph nodes at imaging before surgery. Seven patients underwent full lymphadenectomy; the median number of removed lymph nodes was 41 (range, 22–59). Among these patients, 4 have lymph nodal involvement. The median number of metastatic nodes was 3 (range, 1–29). Three patients underwent a partial lymphadenectomy for bulky nodes. The median number of removed lymph nodes in

TABLE 2. Surgical procedures performed in patients undergoing cytoreduction with PlasmaJet

Procedure	N (%)
TAH/BSO	8 (42%)
Extraperitoneal hysterectomy*	5 (26%)
Bilateral salpingo-oophorectomy (prior hysterectomy)	2 (10%)
Splenectomy	2 (10%)
Gastric resection	1 (5%)
Omentectomy	14 (73%)
Full-thickness diaphragmatic resection	5 (26%)
Appendectomy	8 (42%)
Colon resection	2 (10%)
Abdominal wall resection and repair	2 (10%)
Systematic pelvic and paraaortic lymphadenectomy	7 (37%)
Lymph node sampling	4 (21%)

*En bloc excision of uterus, adnexa, proximal vagina, and rectosigmoid.
TAH/BSO indicates total abdominal hysterectomy/bilateral salpingo-oophorectomy.

TABLE 3. Anatomic region treated with the PlasmaJet

	Number (%)
Abdominal peritoneum	14 (74%)
Paracolic fossa	6 (32%)
Douglas peritoneum/pararectal space	11 (58%)
Bladder peritoneum	3 (16%)
Abdominal wall	3 (16%)
Intestinal mesentery	11 (58%)
Bowel serosa	11 (58%)
Rectosigmoid	6 (32%)
Small bowel	4 (21%)
Colon	3 (16%)
Stomach	2 (16%)
Upper abdomen	14 (74%)
Diaphragm	13 (68%)
Liver surface	4 (21%)

these patients was 5 (range, 4–7). All of these patients have lymph nodal involvement with a median number of metastatic nodes of 2 (range, 2–3).

In all patients, a complete resection of all macroscopic disease was achieved. The abdominopelvic cavity was divided into 4 anatomic regions. The regions are listed in Table 3. For each region, the use of PlasmaJet was possible. The median number of organs treated by PlasmaJet was 3 (range, 1–7). In total, we treated 66 organs with PlasmaJet in 19 patients. Figures 1 and 2 show the use of PlasmaJet on the diaphragm and the small bowel.

Six patients (32%) had intraoperative complications. Five patients required blood transfusion, and one of them also needed the administration of frozen plasma. The only major intraoperative complication was a ureteral injury, which required double-j stent (not during use of PlasmaJet). The median length of hospital stay was 9 days (6–21 days). Eight patients (42%) had postoperative complications. One patient developed pneumonia and was successfully treated with antibiotics. Three patients needed blood transfusions postoperatively. Two patients had a urinary tract infection. One patient developed a wound infection and necrosis requiring a 21-day hospital stay. In this patient, during surgery, abdominal port-site metastases were removed. One patient developed a pneumothorax. In this patient, a full-thickness diaphragmatic resection was performed, done during surgery.

No bowel or urological fistulas occurred. According to the Clavien-Dindo classification,[10] 13 (93%) adverse events grade 1 or 2 were recorded. We observed only 1 (7%) grade 3 adverse event. No mortality was reported.

The median follow-up after cytoreduction was 8 months (range, 0–17). During this period, 6 patients had a relapse. To date, 13 (68%) are alive without disease, 4 (21%) are alive with disease, and 2 patients (10%) died of disease.

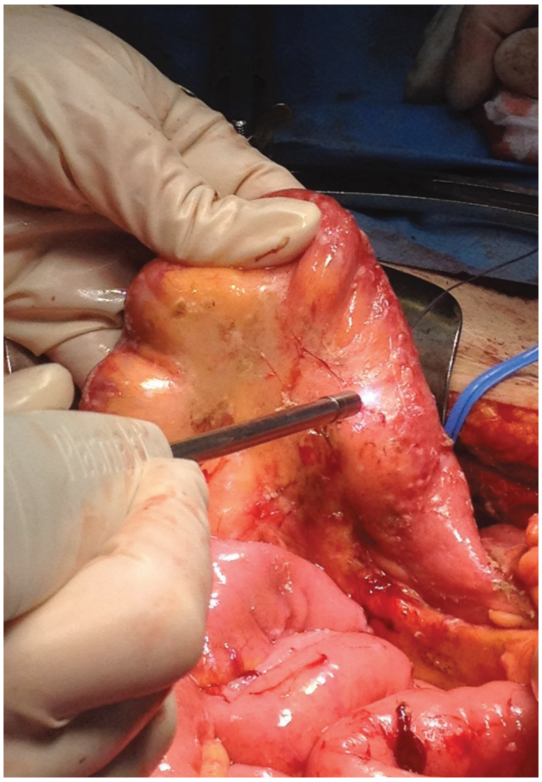

FIGURE 1. PlasmaJet ablation of carcinomatosis on the small bowel.

DISCUSSION

To the best of our knowledge, this report represents the largest series on the use of the PlasmaJet in ovarian cancer. In our series, the PlasmaJet seems to be an efficient device for tumor ablation or dissection to obtain complete resection of all macroscopic disease in patients with peritoneal carcinomatosis.

The PlasmaJet was widely used in this study on every tumor deposit on several organs. In particular, the PlasmaJet facilitated the removal of disease on the bowel serosa and might reduce the need for bowel resection. In this series, all patients

FIGURE 2. PlasmaJet ablation carcinomatosis on the diaphragm.

were resected to no macroscopic residual tumor, and no fistulas occurred. Further experience and a longer follow-up period are required to establish the use of the PlasmaJet in cytoreductive surgery of ovarian cancer.

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